Collectivity in the Co isotopes around ^{68}Ni studied in the β-decay of ^{65,66,67}Fe at LISOL

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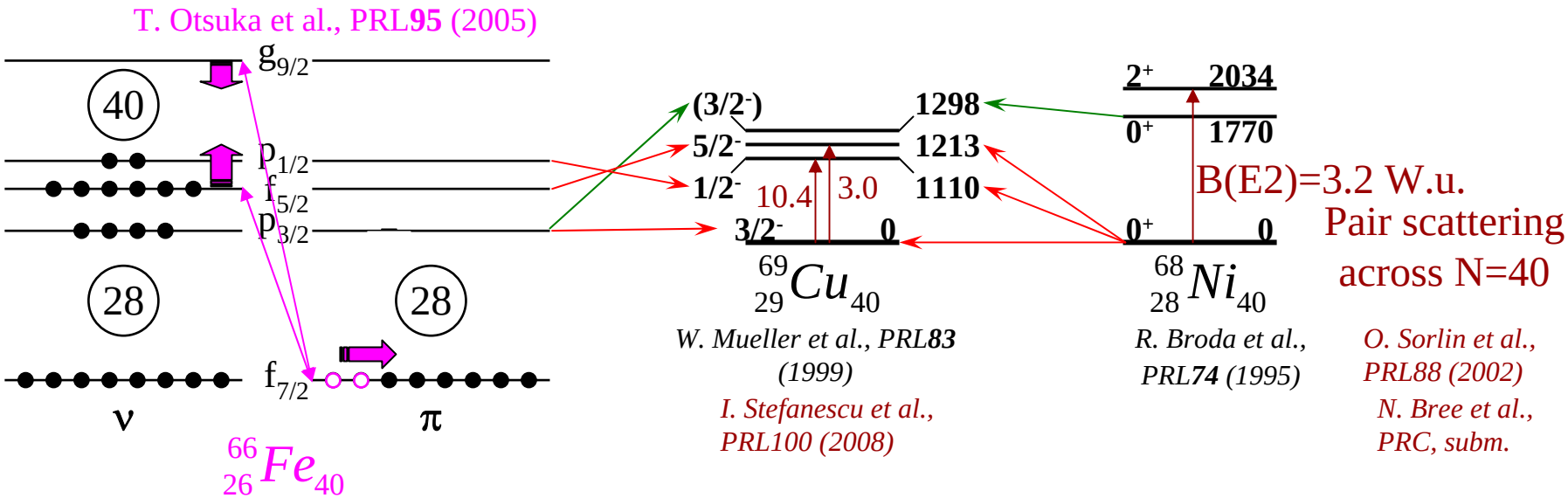
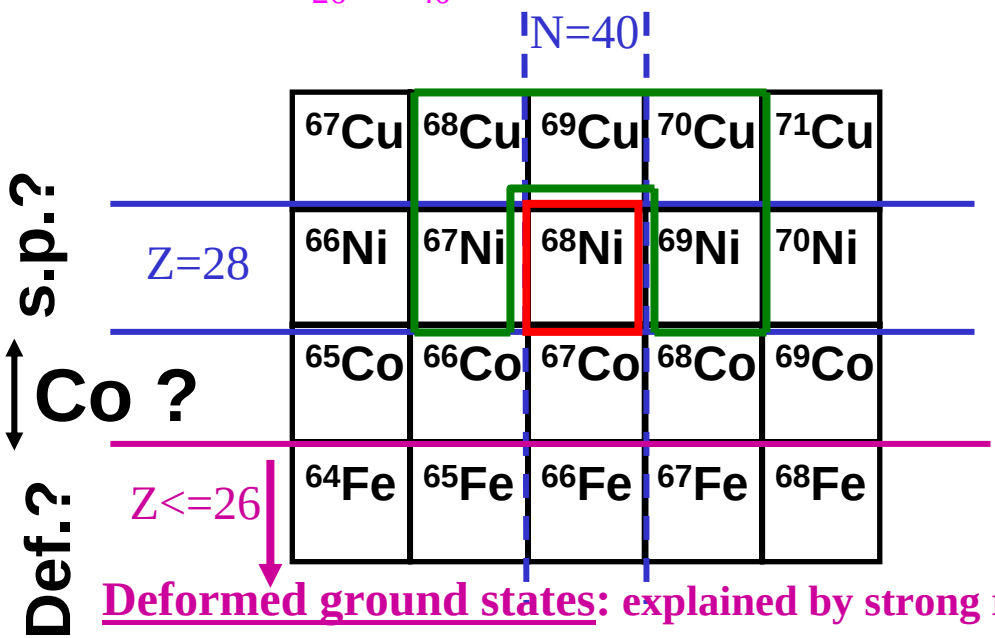
Outline

- Introduction in the Z~28 and N~40 region and motivation
- Experimental set-up: LISOL
- Illustrative example of results: ^{67}Fe β-decay
- ^{65,66,67}Co level schemes: discussion and interpretation
- Conclusion and outlook

Nuclear structure at Z~28 and N~40





s.p. states coupled to ^{68}Ni core

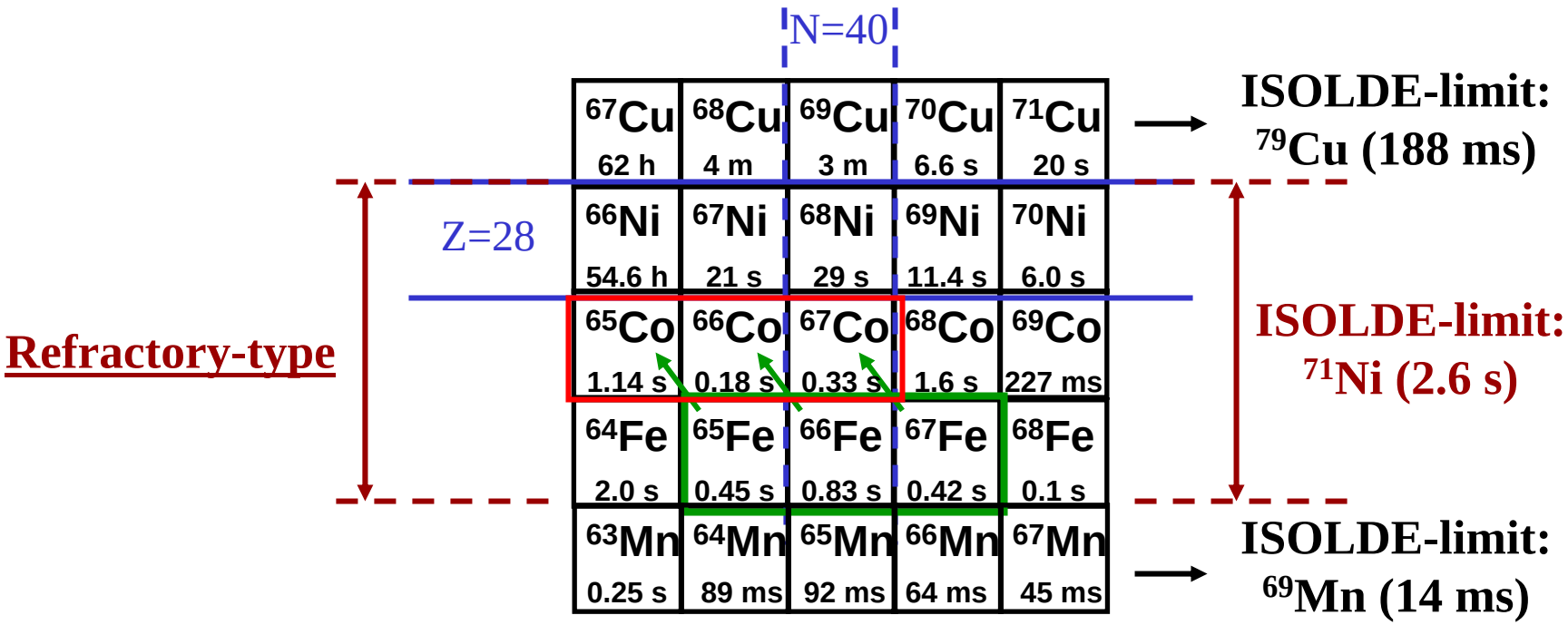
- β-decay studies @ LISOL
- Coulex of Cu and Ni isotopes @ ISOLDE
- Transfer reactions (^{67}Ni) @ ISOLDE

^{66}Fe: β_2~0.26 (M. Hannawald et al., PRL82 (1999))

^{64}Cr: β_2~0.3 (O. Sorlin et al., EPJA19 (2003))

Deformed ground states: explained by strong rep. $\pi f_{7/2}$-$\nu g_{9/2}$ and attr. $\pi f_{7/2}$-$\nu f_{5/2}$ interaction

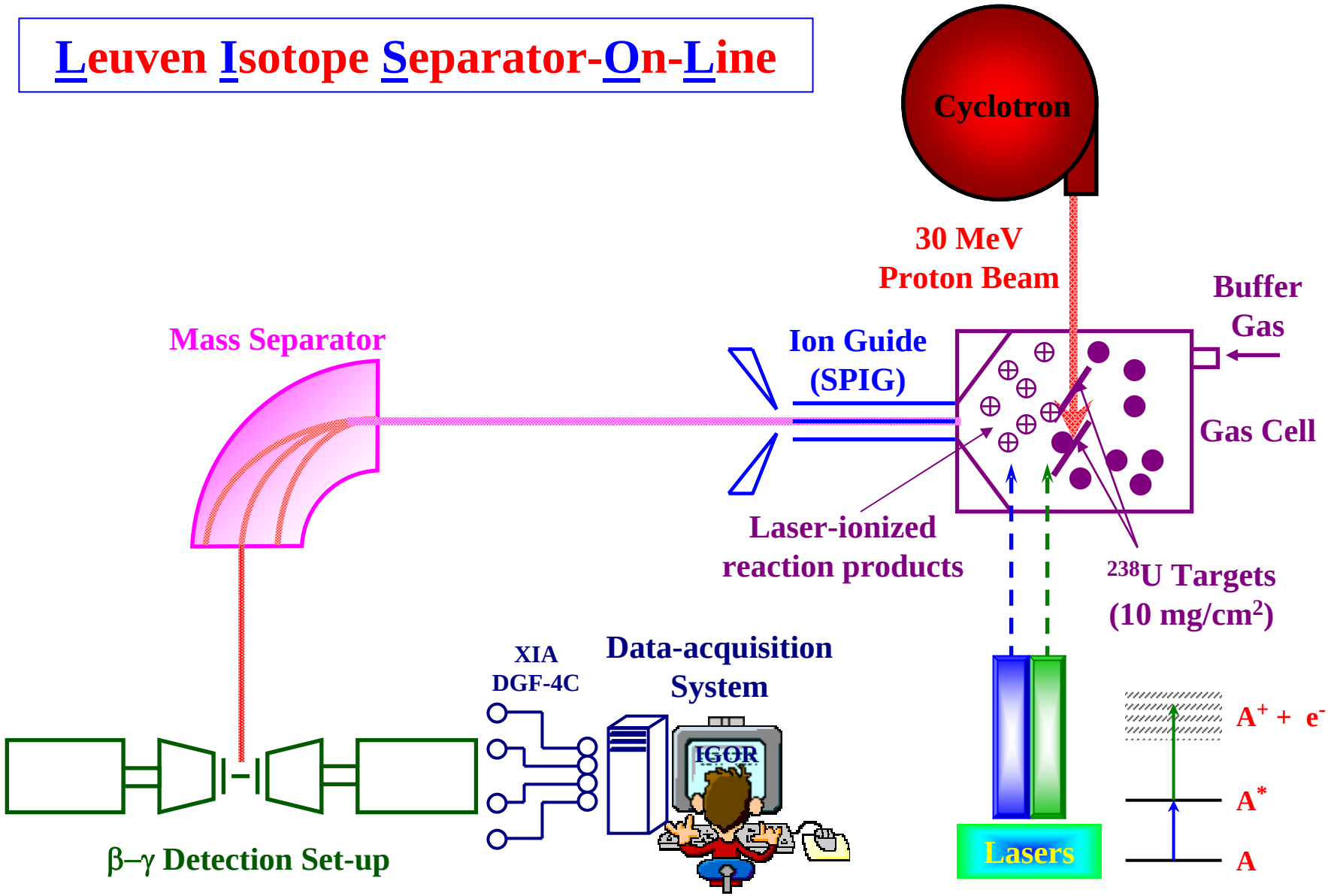
Fe β-decay studies: production



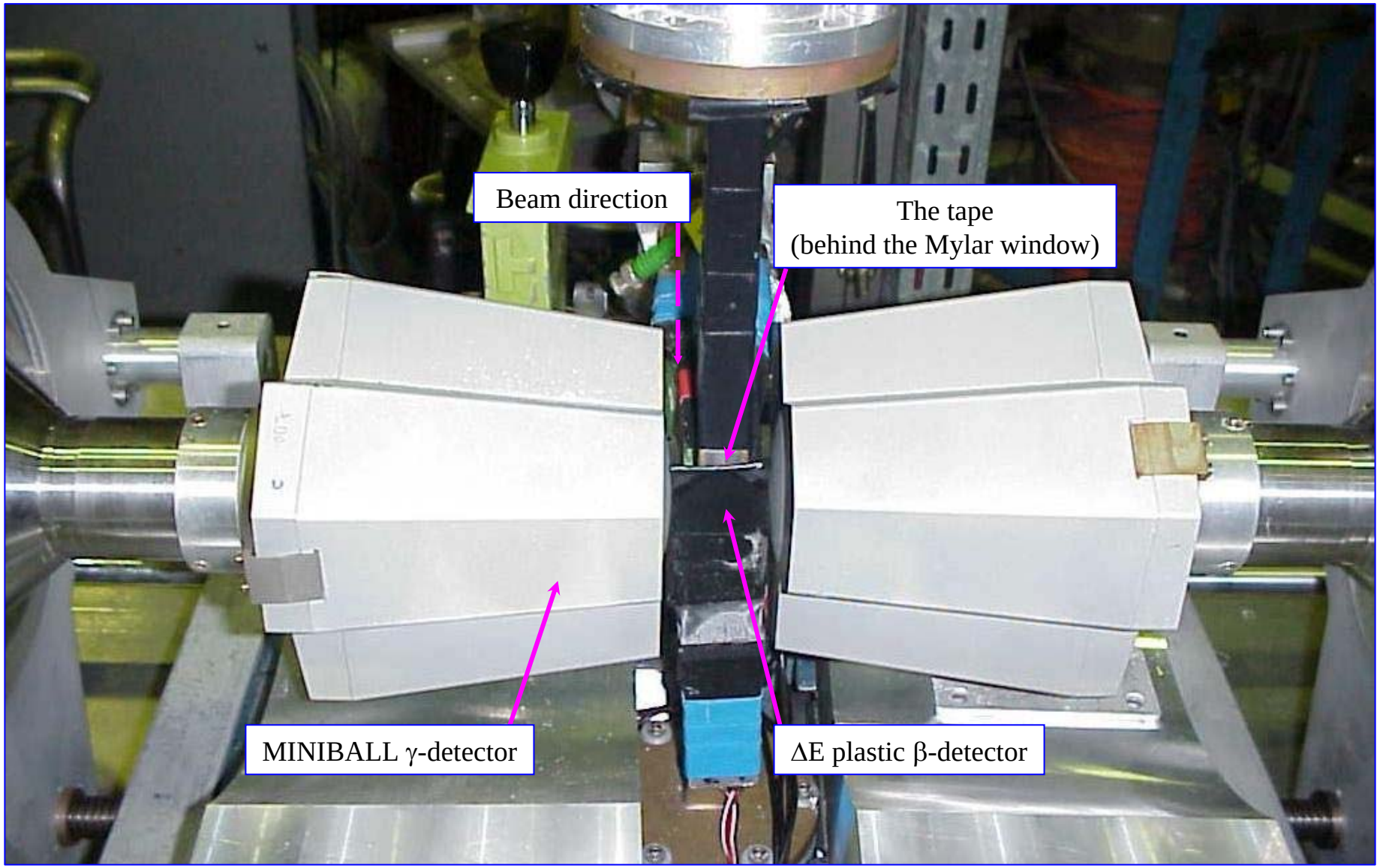
- In-flight techniques
- Thin target ISOL systems

Experimental set-up

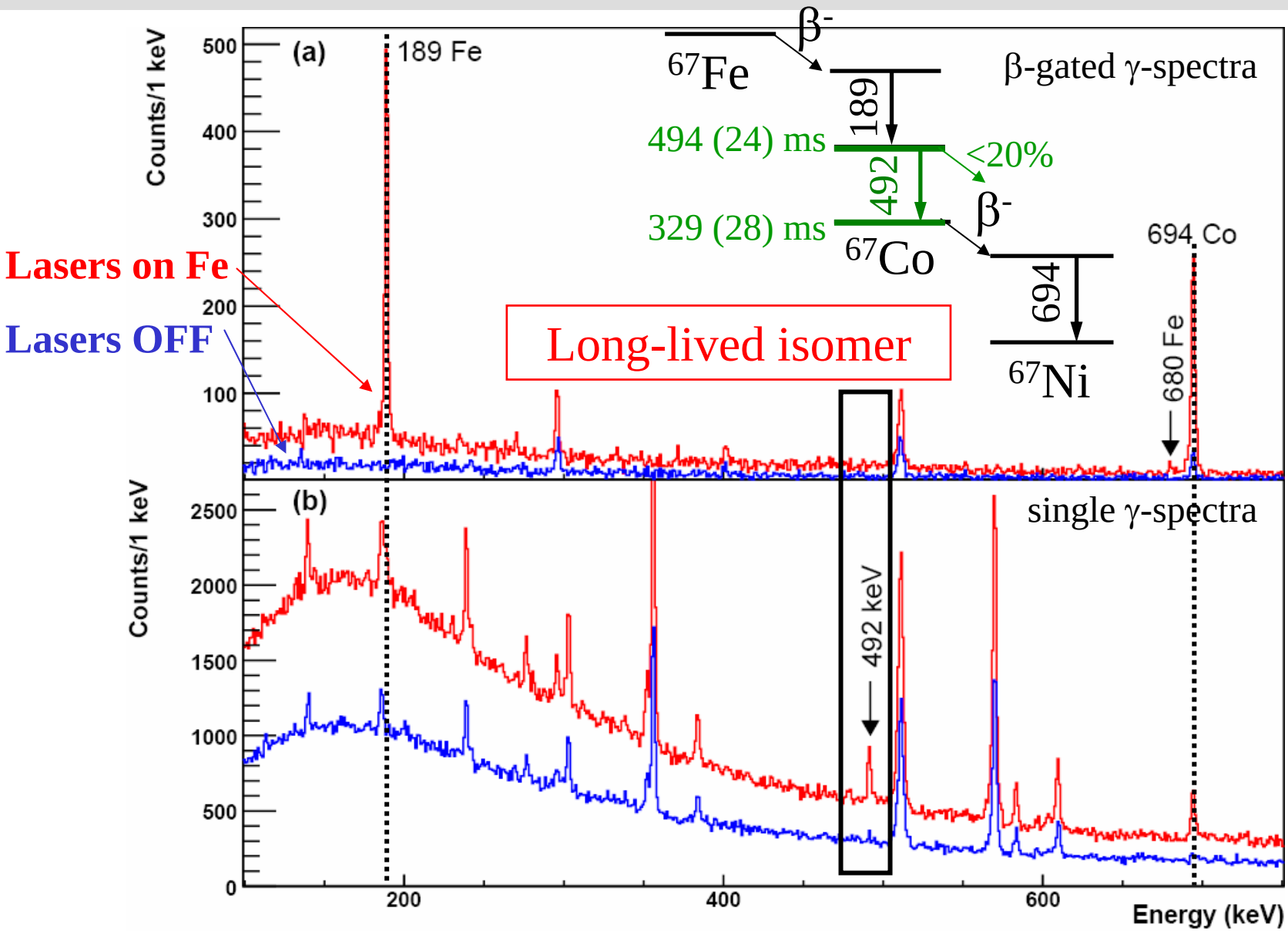
Leuven Isotope Separator-On-Line



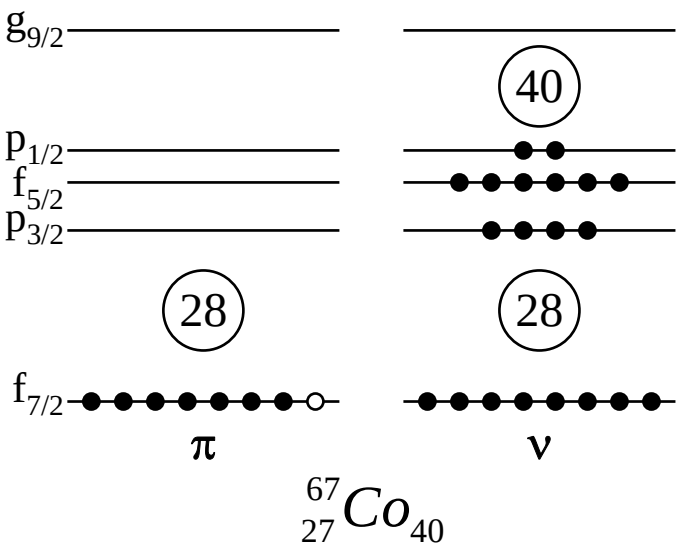
Detection setup

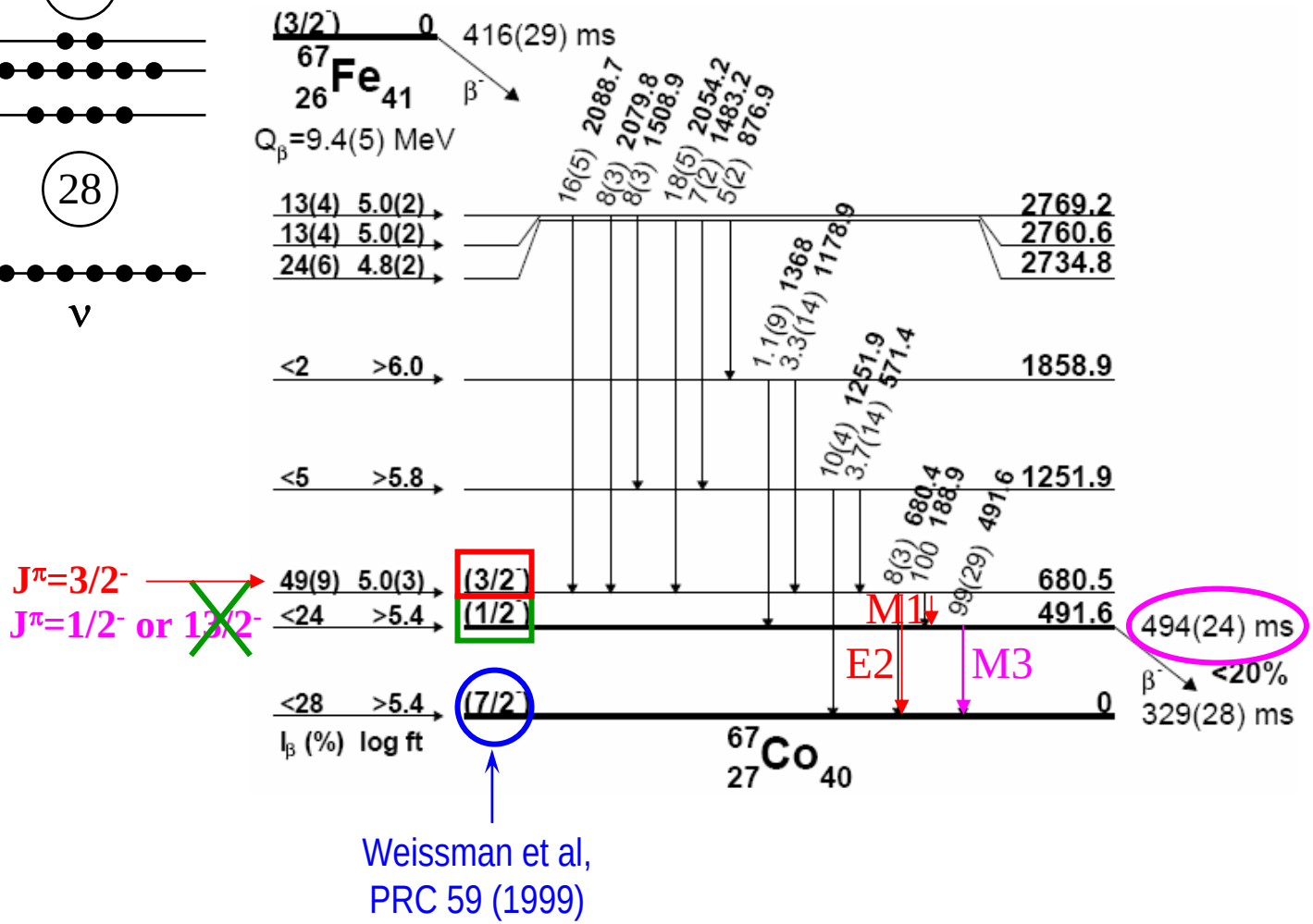


^{67}Fe decay: β-gated vs. single γ spectrum



Decay scheme ^{67}Fe

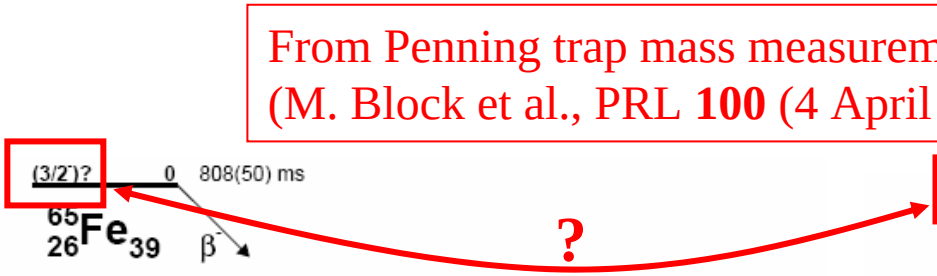


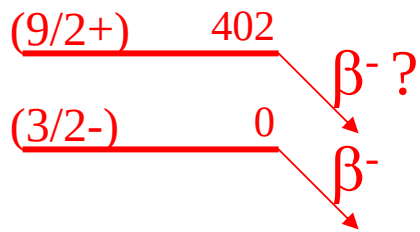


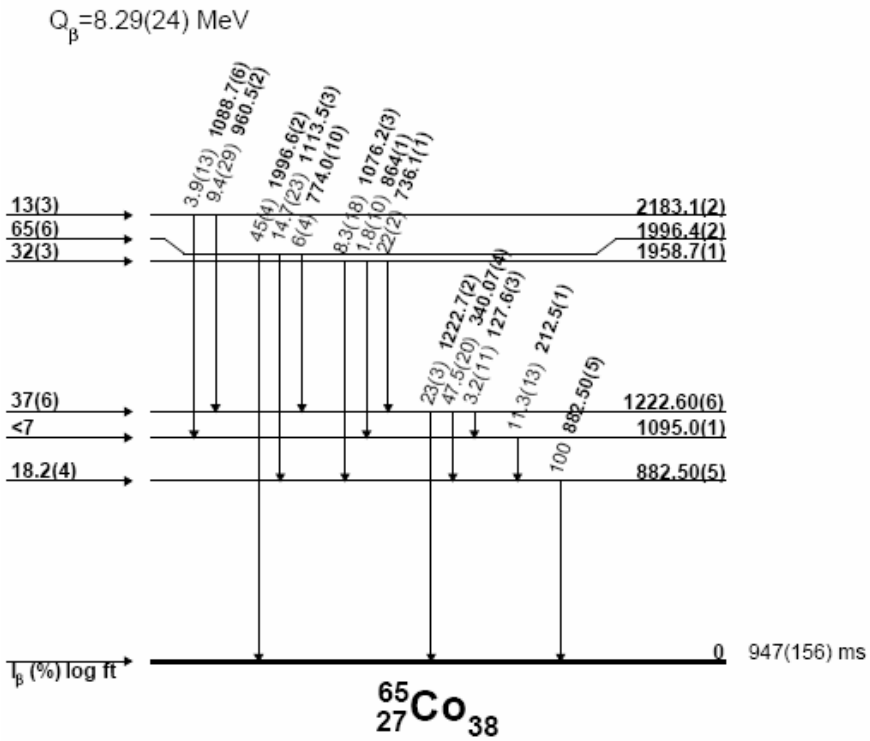
Weissman et al,
PRC 59 (1999)

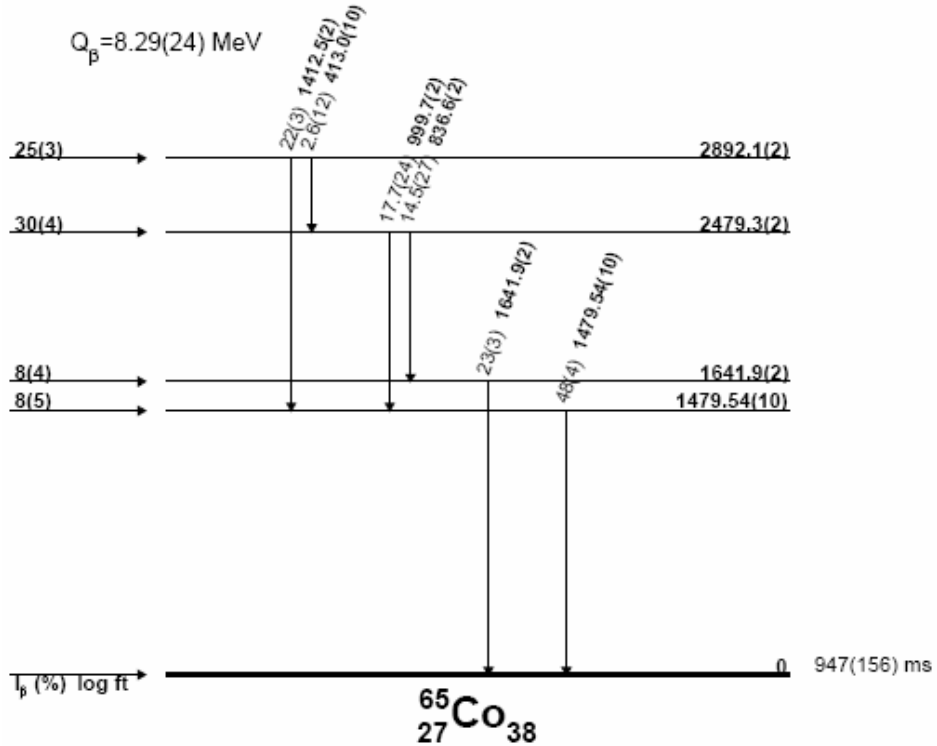
Decay scheme ^{65}Fe

From Penning trap mass measurements @ MSU
(M. Block et al., PRL **100** (4 April 2008) 132501)







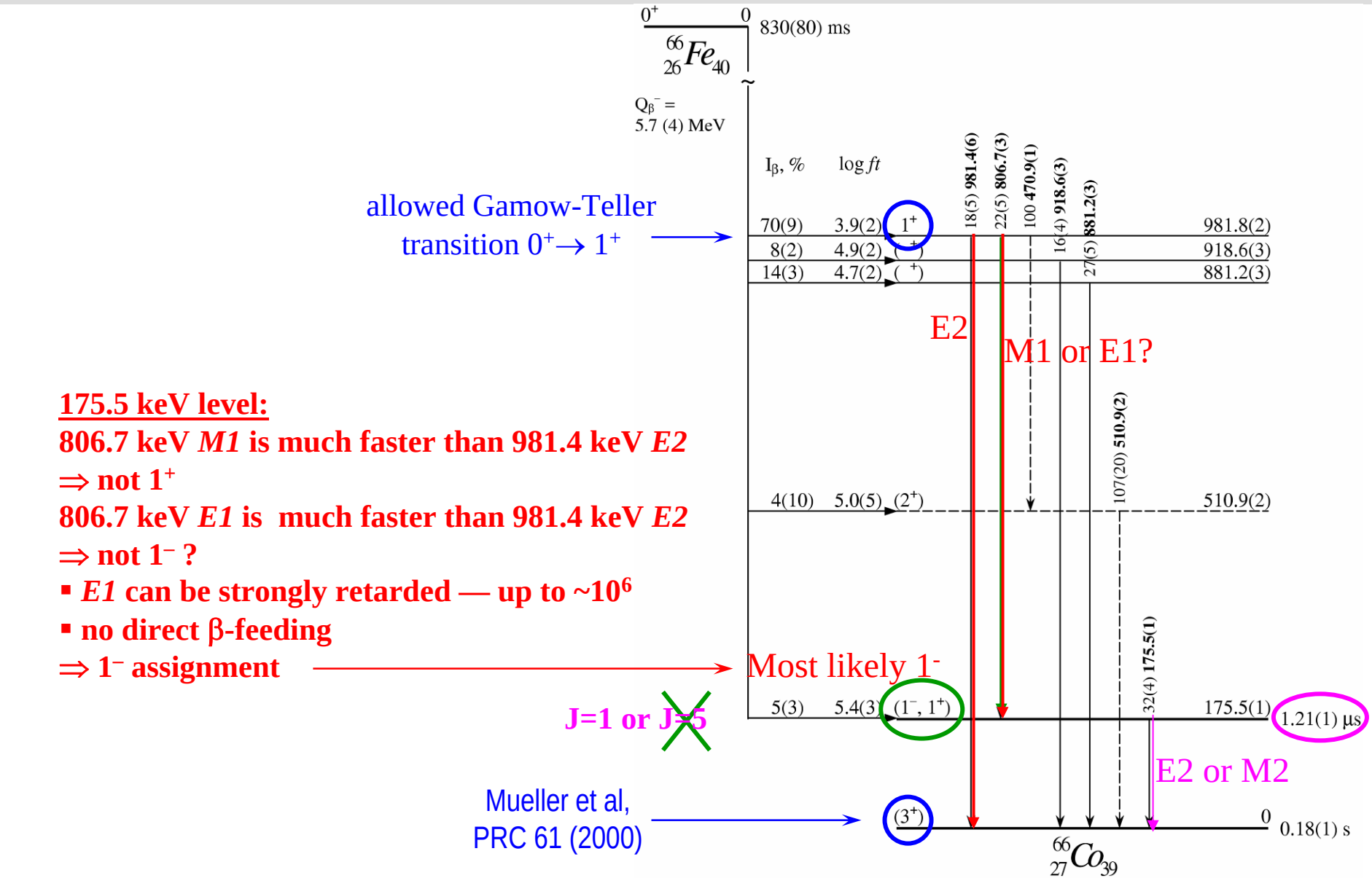


^{65}Co level scheme, 1st branch.

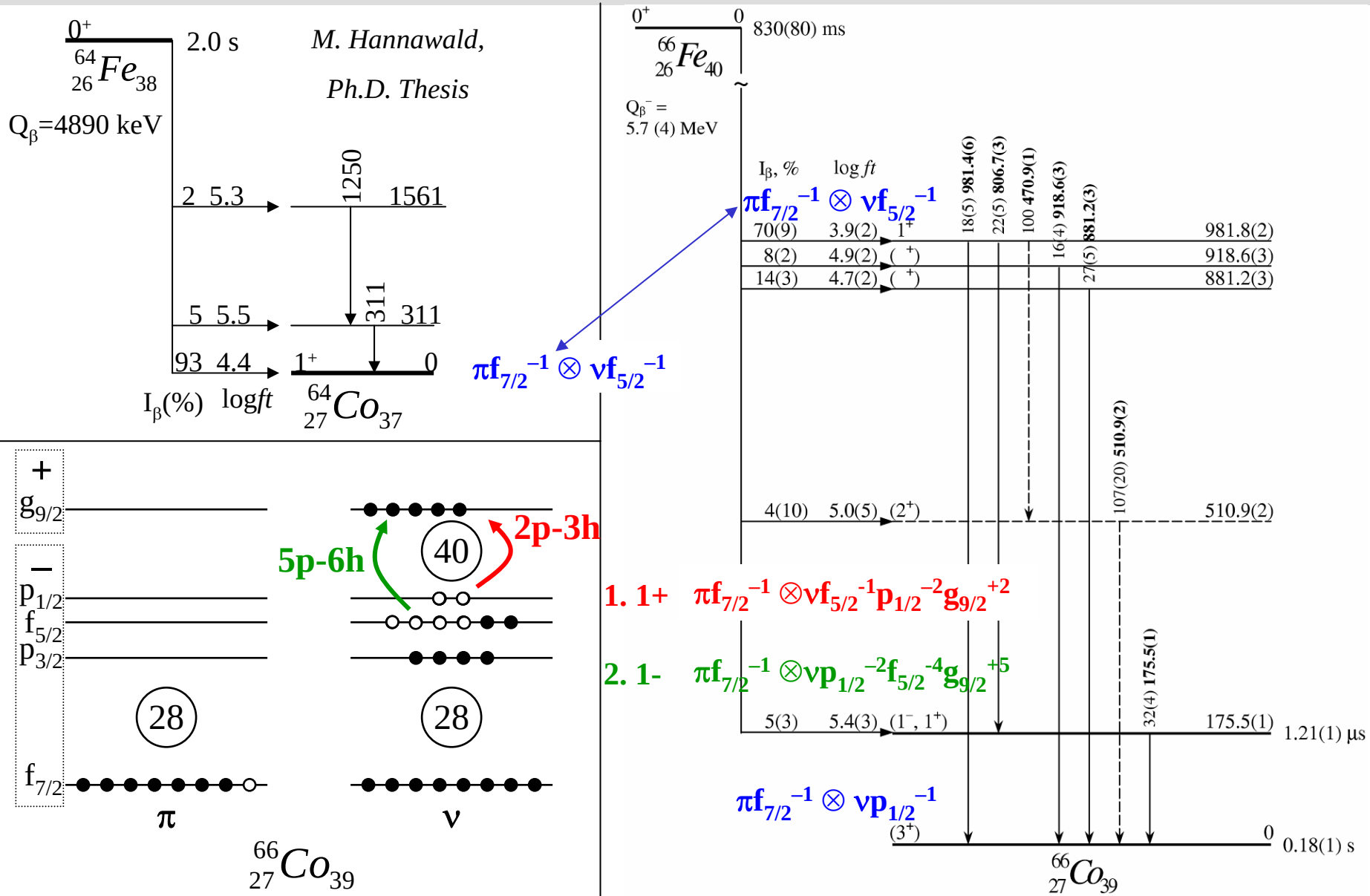
^{65}Co level scheme, 2nd branch.

Two independent branches: cannot be resolved on the half-life basis

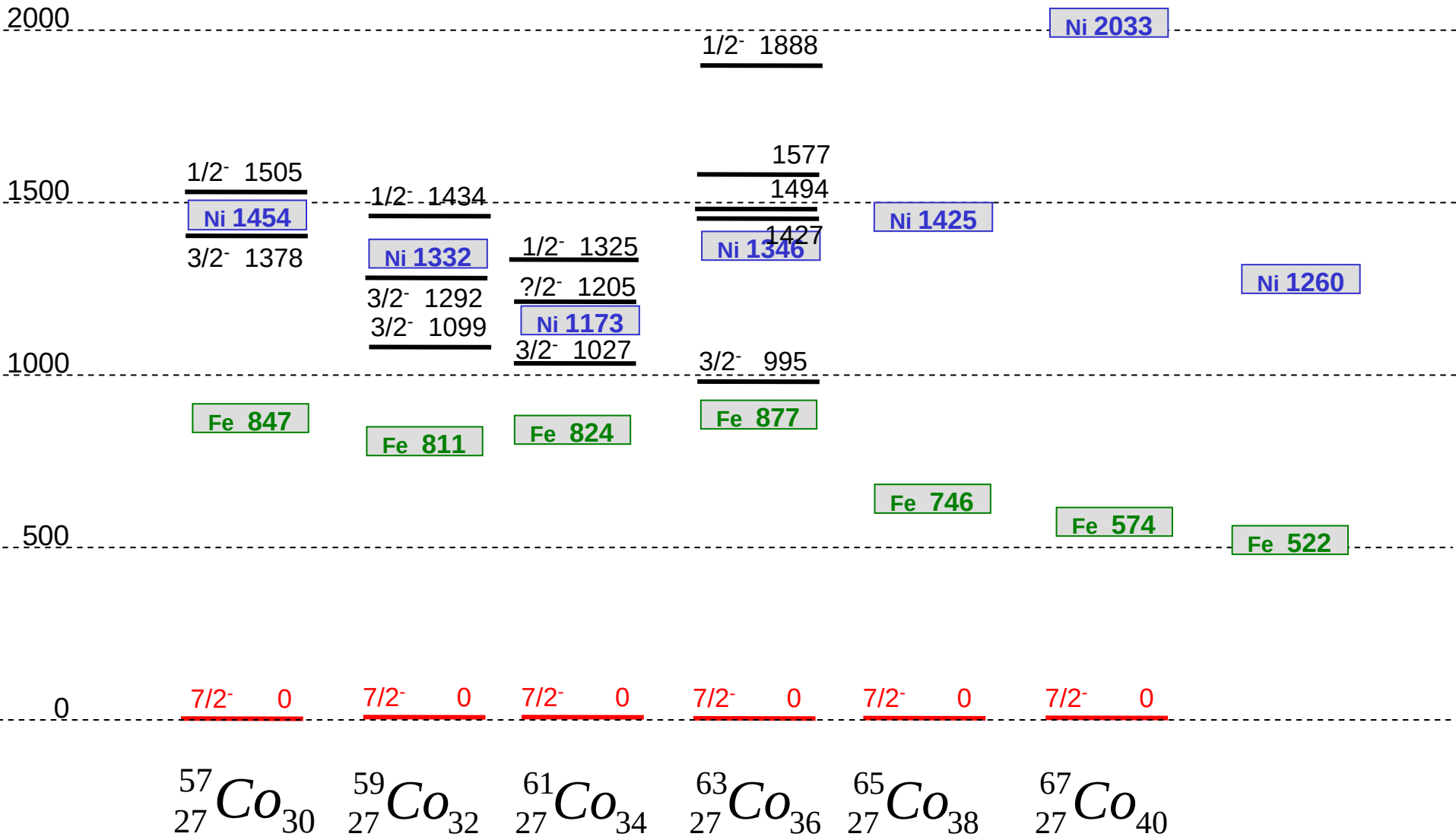
Decay scheme ^{66}Fe



Interpretation ^{66}Co



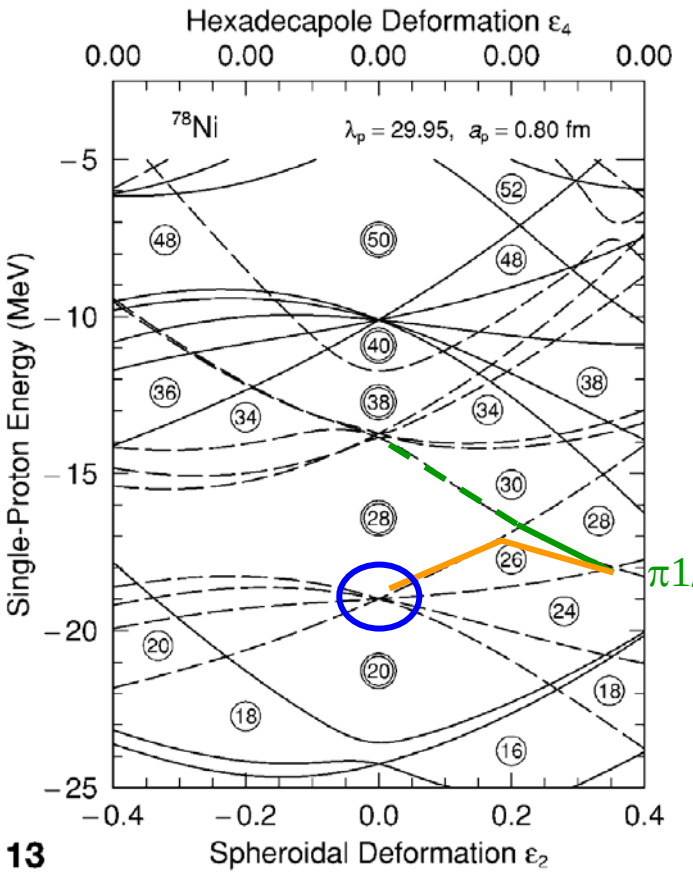
Odd Co systematics



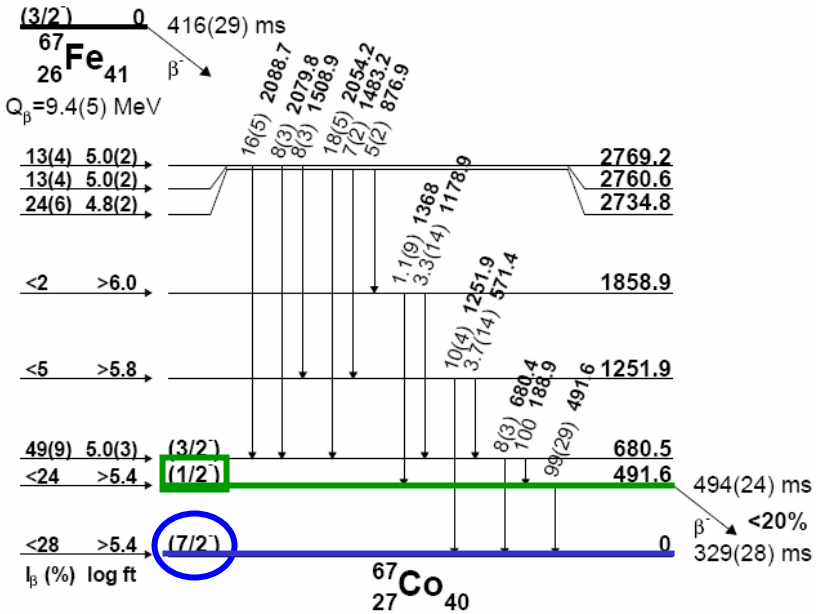
Interpretation ^{67}Co

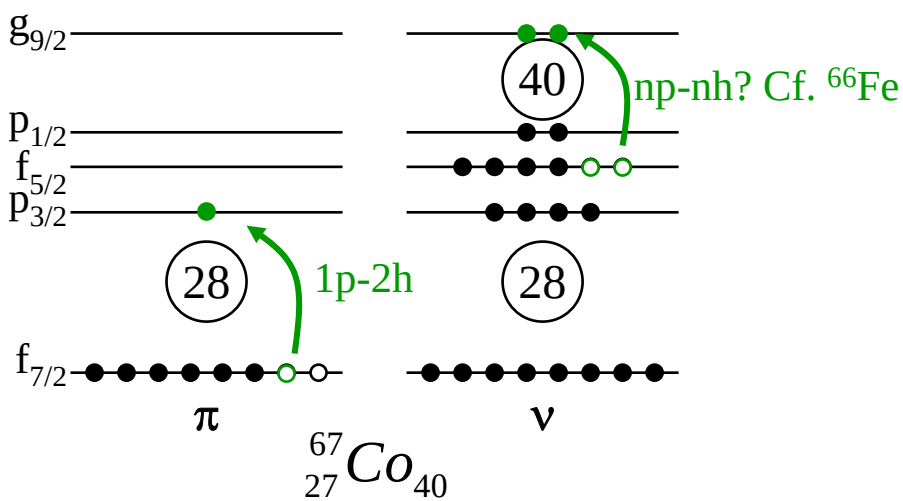
(7/2$^-$) g.s. **Spherical**

(1/2$^-$) isomer **Deformed**



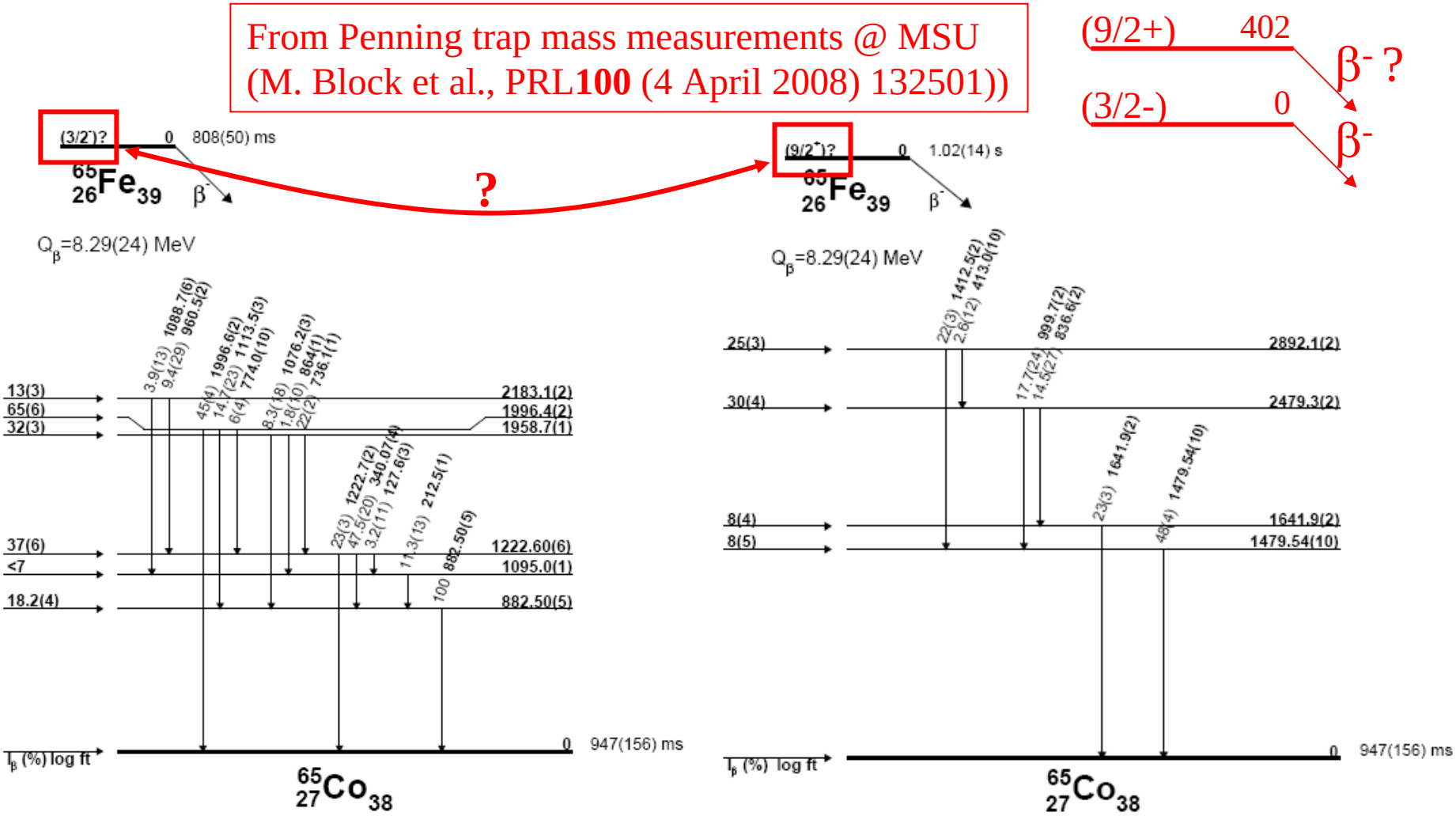
π1/2$^-$[321]





Decay scheme ^{65}Fe

From Penning trap mass measurements @ MSU
(M. Block et al., PRL**100** (4 April 2008) 132501))



^{65}Co level scheme, 1st branch.

^{65}Co level scheme, 2nd branch.

Two independent branches: cannot be resolved on the half-life basis

Decay scheme ^{65}Fe

From Penning trap mass measurements @ MSU
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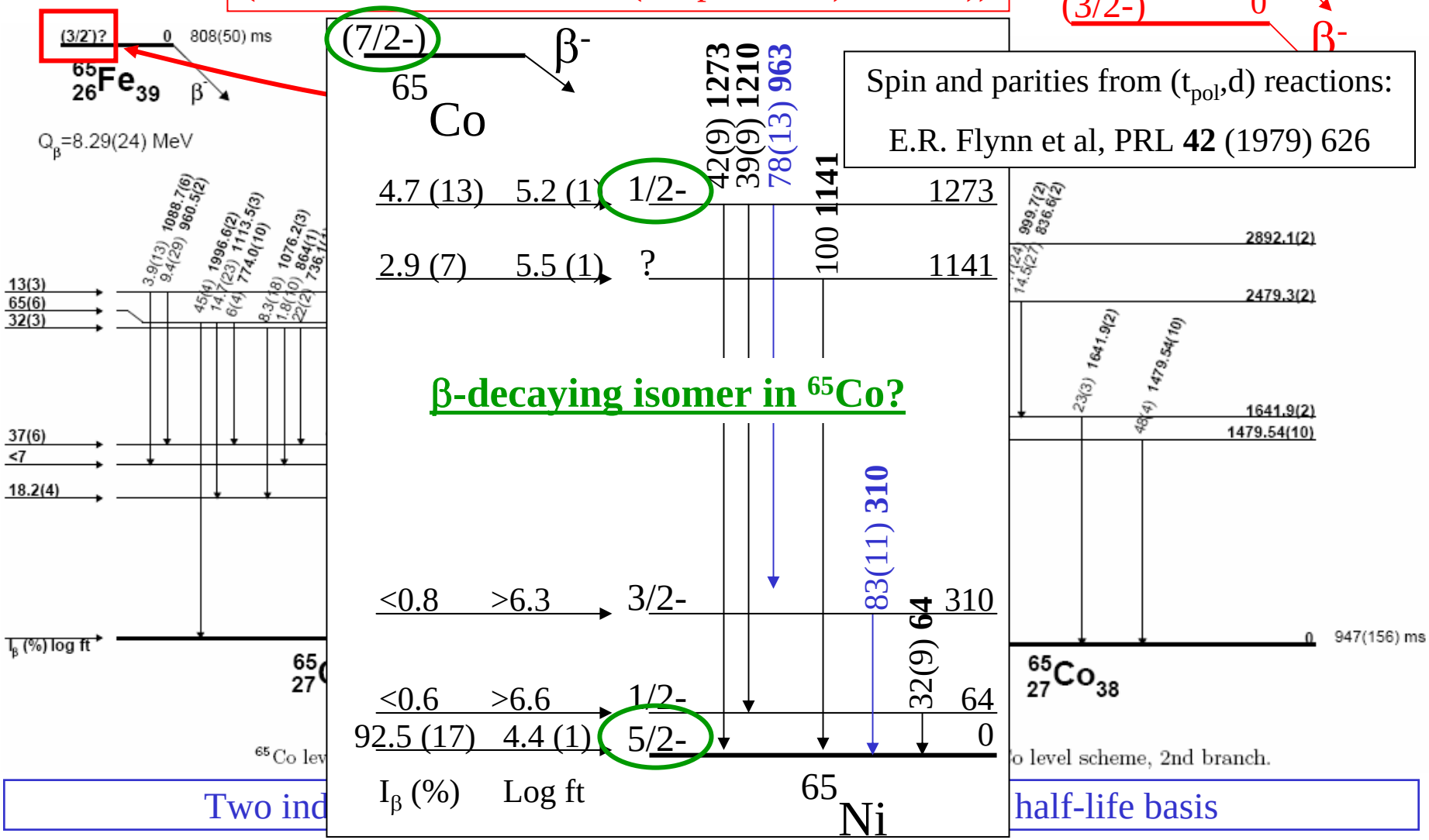
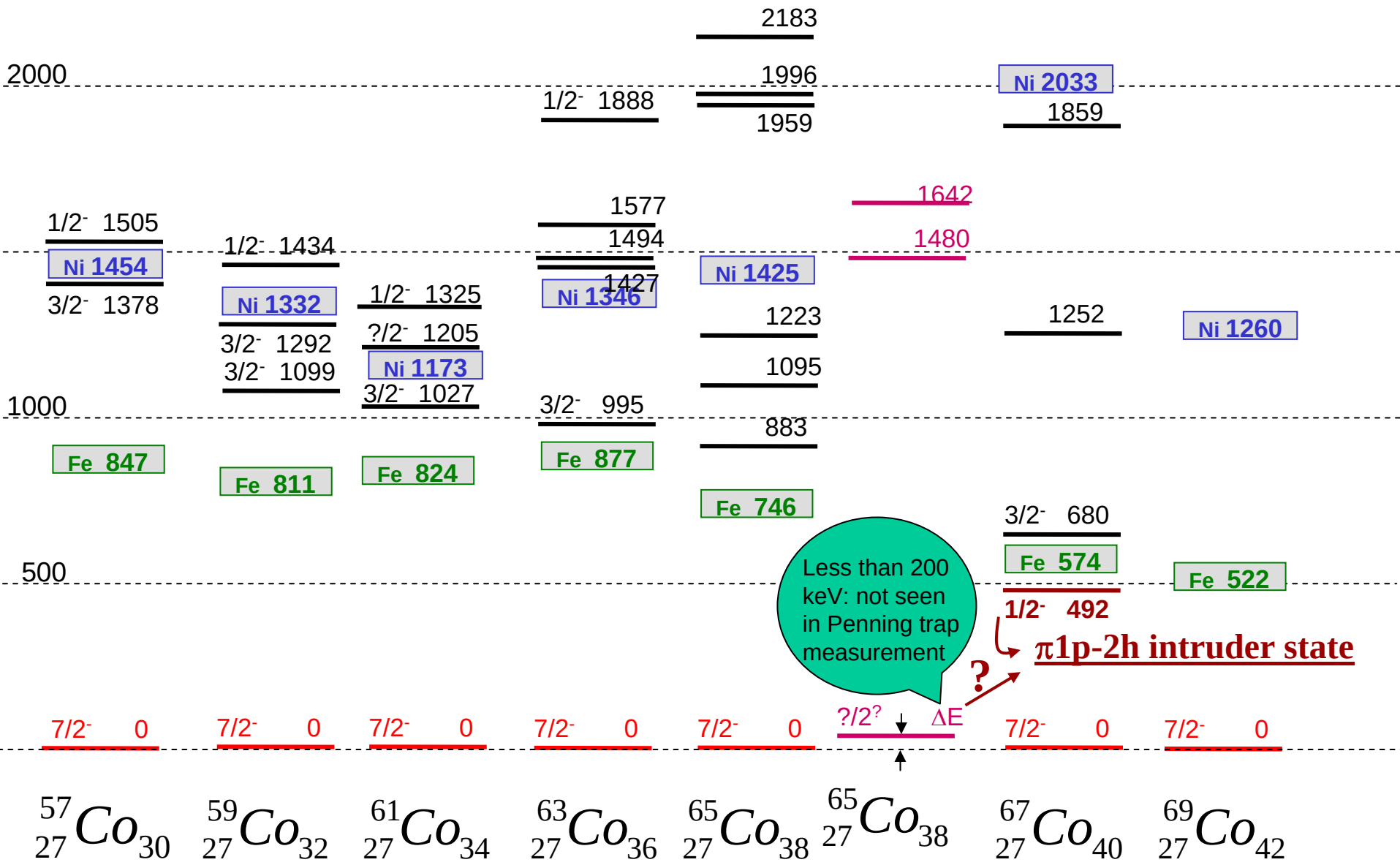


Two ind half-life basis

Odd Co systematics



Odd Co systematics

Intruder states in odd-mass nuclei near closed shells

K.Heyde et al., Phys. Rep. (1983)

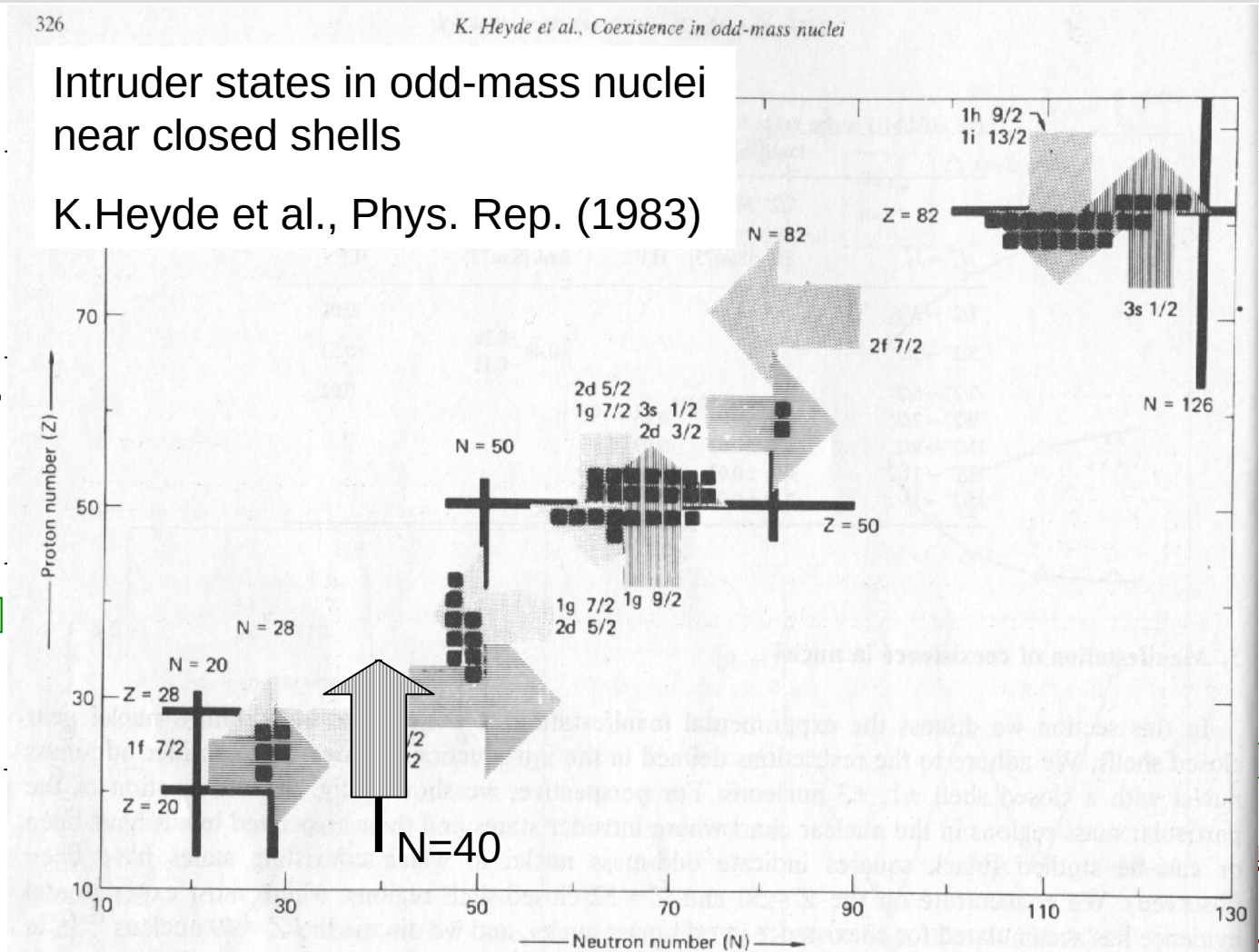


Fig. 3.1. Schematic nuclear mass chart. The odd-mass nuclei near closed shells (±1, ±3 nucleons) in which intruder states from across the major shell closure have been identified are given as black squares. The arrows (using lines) involve the promotion of the specific indicated nucleon configuration (nlj) across a major shell (creating a 1h–2p configuration). The arrows (dotted) imply a nucleon configuration moving down into the filled shell (creating a 1p–2h configuration). Only excitations down to $N, Z = 28$ are shown. No subshell effects ($Z, N = 40, Z = 64$, etc.) are indicated. Detailed discussions of the individual nuclei are given in section 3.

2000

1/2⁻ 1505

Ni 1454

3/2⁻ 1378

1000

Fe 847

500

7/2⁻ 0

$^{57}_{27}Co_{30}$

Ni 1260

Fe 522

truder state

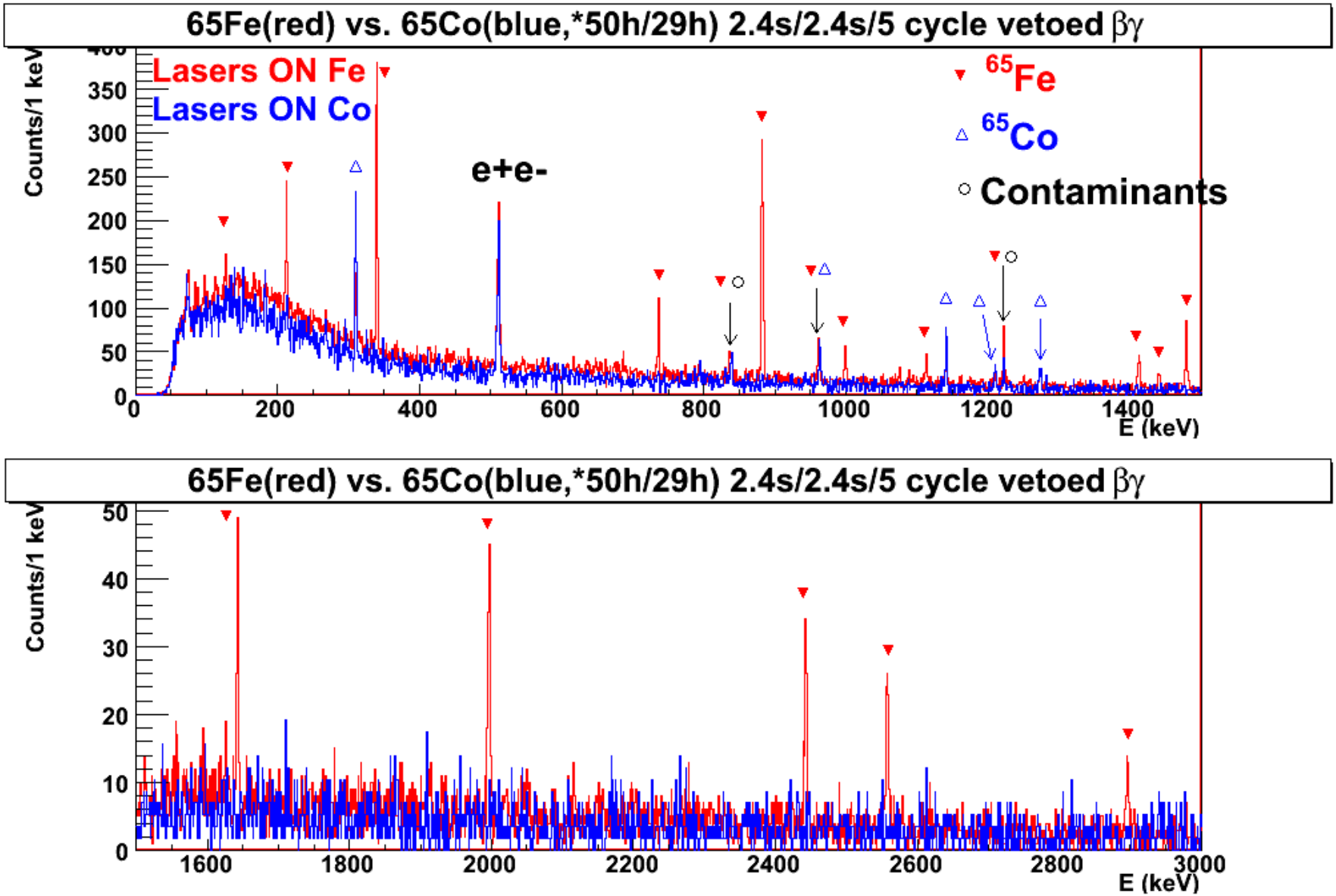
/2⁻ 0

$^{59}_{7}Co_{42}$

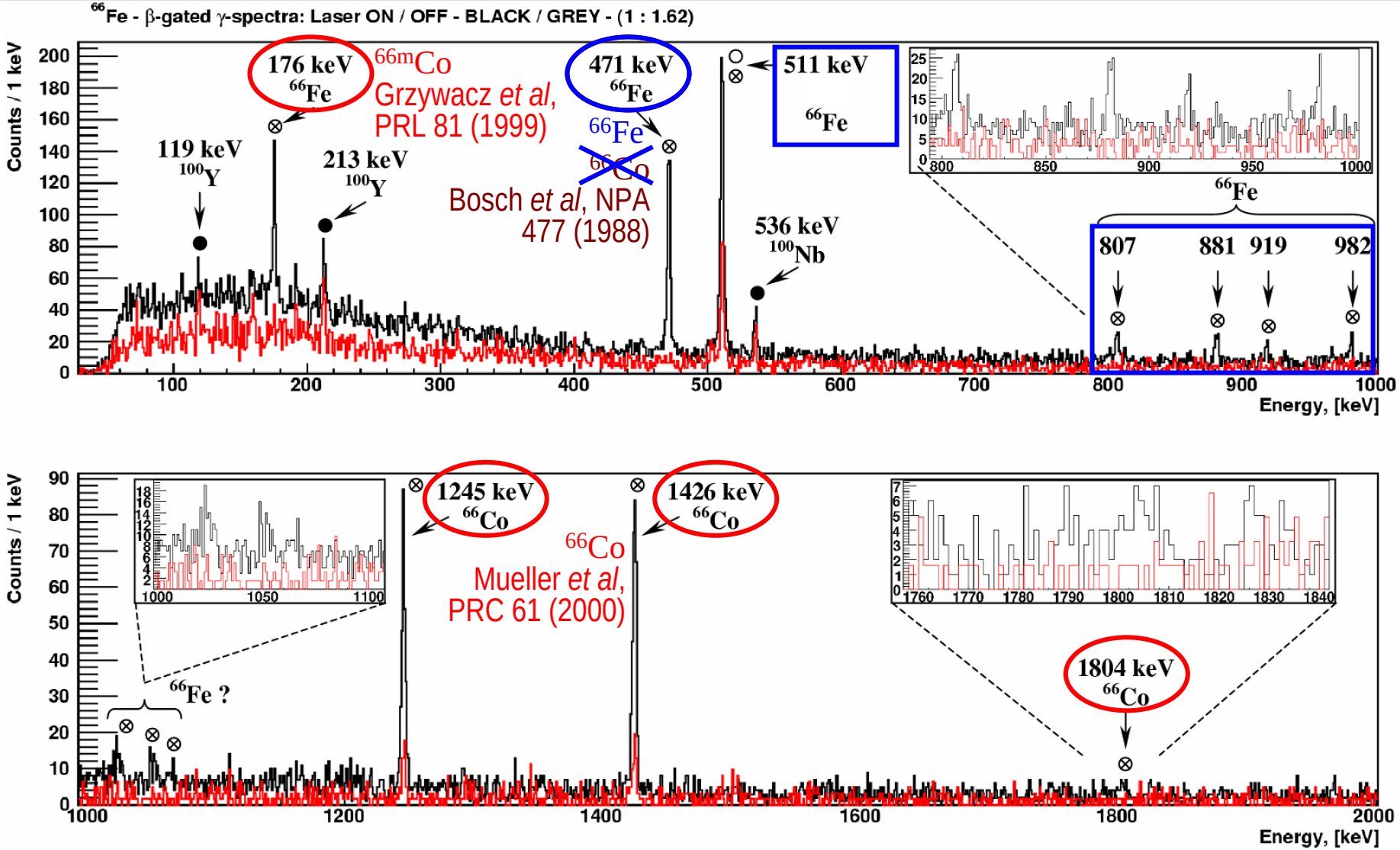
Conclusion and outlook

- Performed ^{65,66,67}Fe β-decay studies
- New correlation technique: 500 ms isomer characterized at 492 keV in ^{67}Co
- Nuclear structure of ^{65,66,67}Co: Evidence for **shape coexistence**
  - ✓ low-lying deformed (1-/1+) intruder state in ^{66}Co: **νnp-nh intruder**
  - ✓ low-lying deformed (1/2-) intruder state in ^{67}Co: **π1p-2h intruder**
  - ✓ low-lying isomer in ^{65}Co?: **π1p-2h intruder**
- Laser-ion source development for enhanced selectivity and faster release times
  - ✓ ^{68}Fe β-decay study becomes feasible @ LISOL
- β-decay of $^{61-70}$Mn at ISOLDE, CERN (24 shifts approved)
- Shell model calculations (after adjustment of current effective interactions)

Results: ^{65}Fe βγ-spectrum

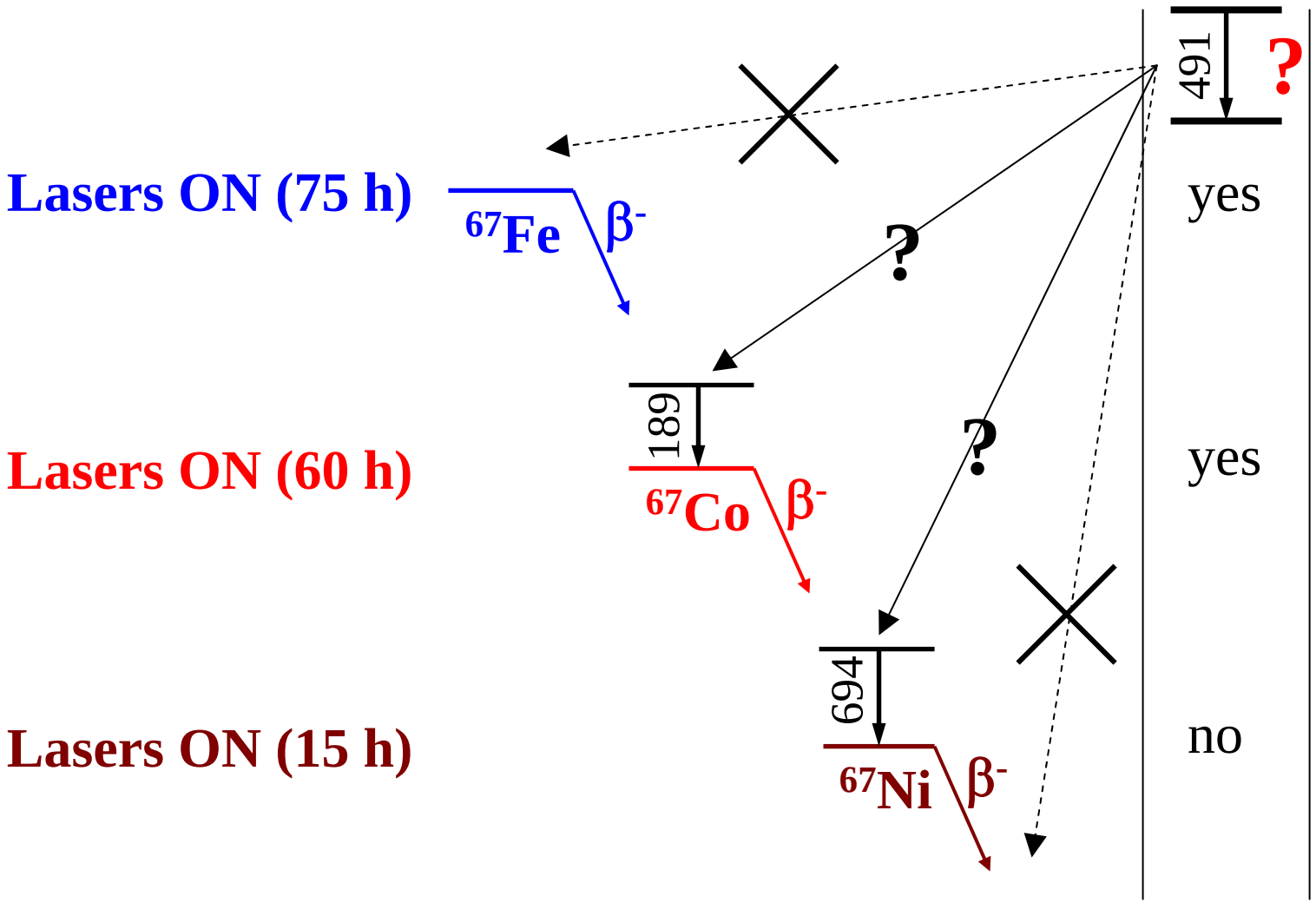


Results: ^{66}Fe βγ-spectrum



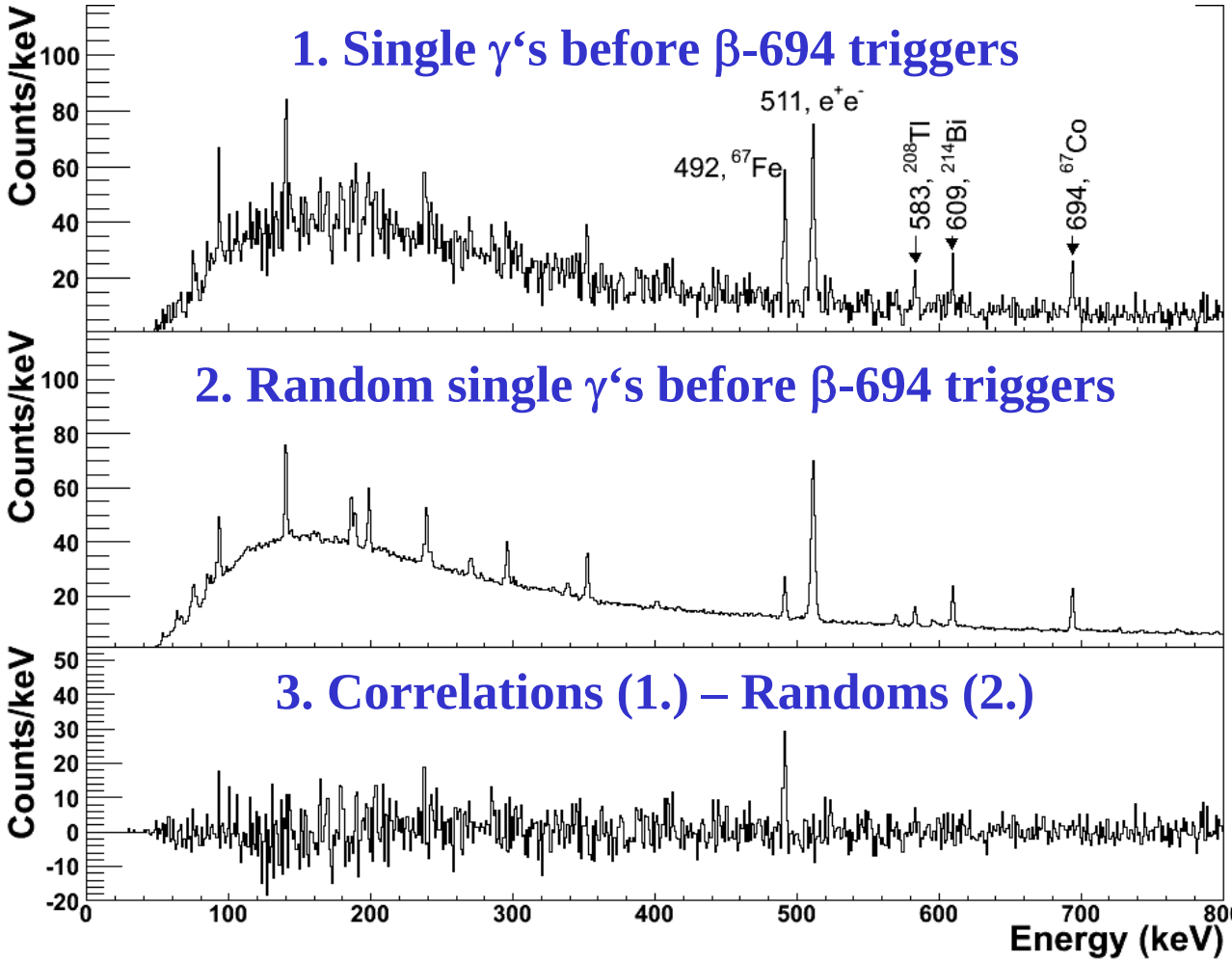
New γ-transitions from the decay of ^{66}Fe were identified

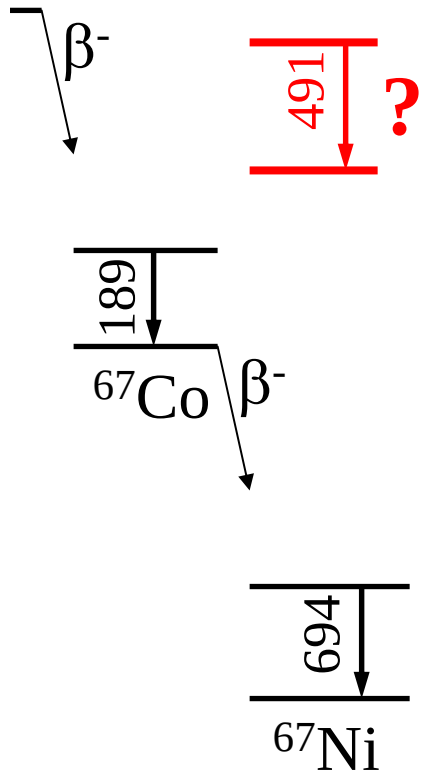
Placing the 492 keV transition

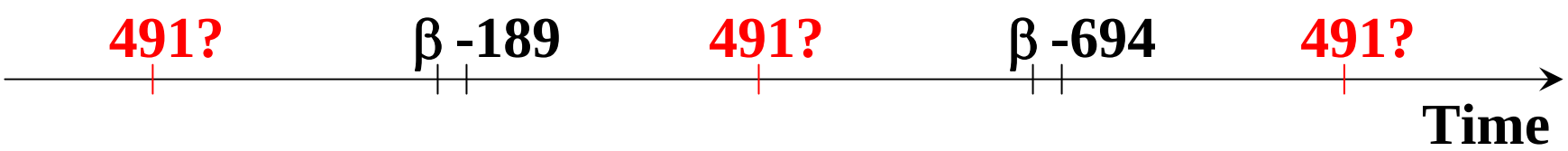


Digital electronics ⇒ Event-by-event data with time stamp ⇒ Event correlations!

Correlations

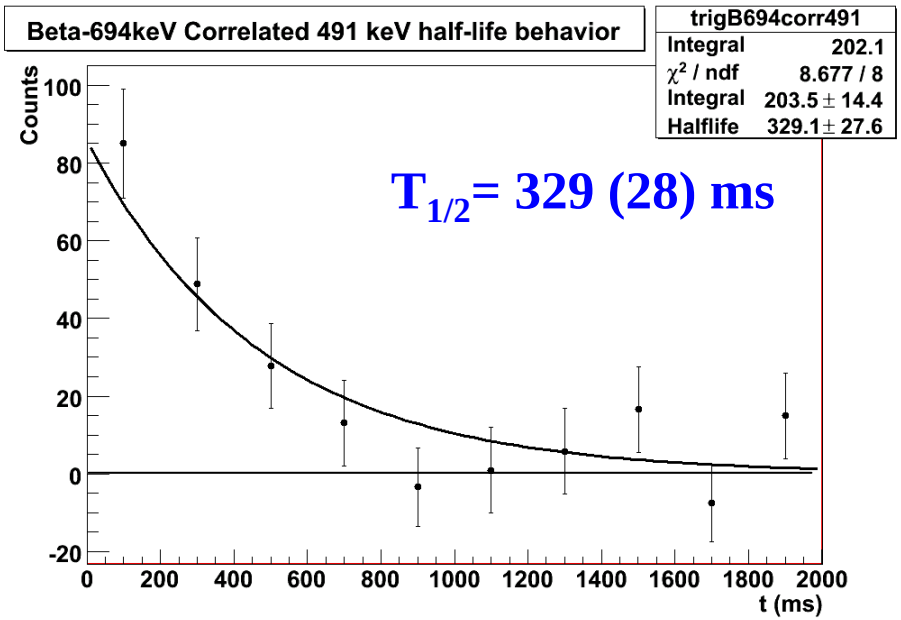




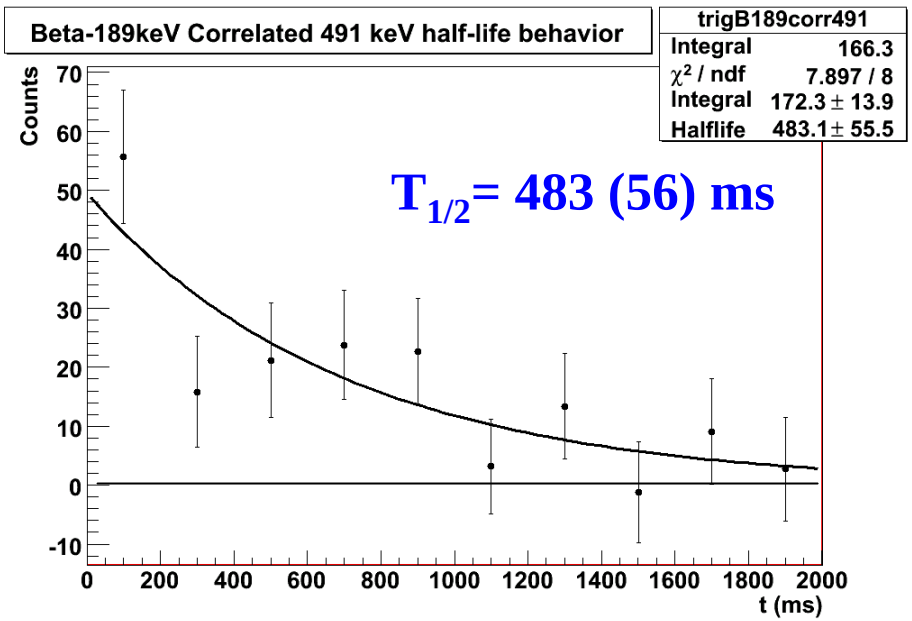


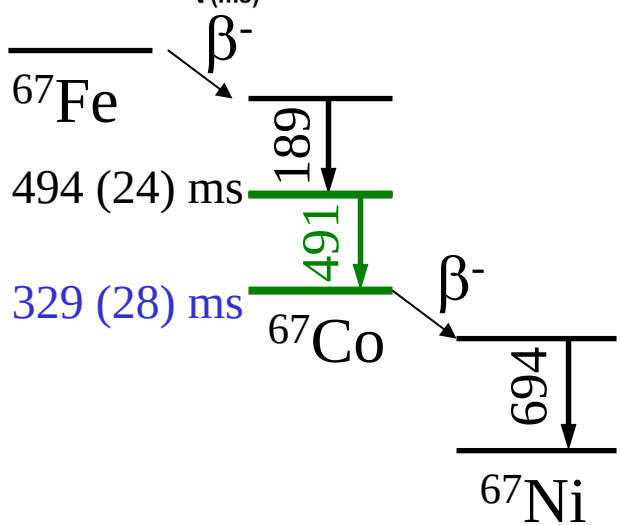
Random subtracted results

491 keV events coming before β-694 keV



491 keV events coming after β-189 keV

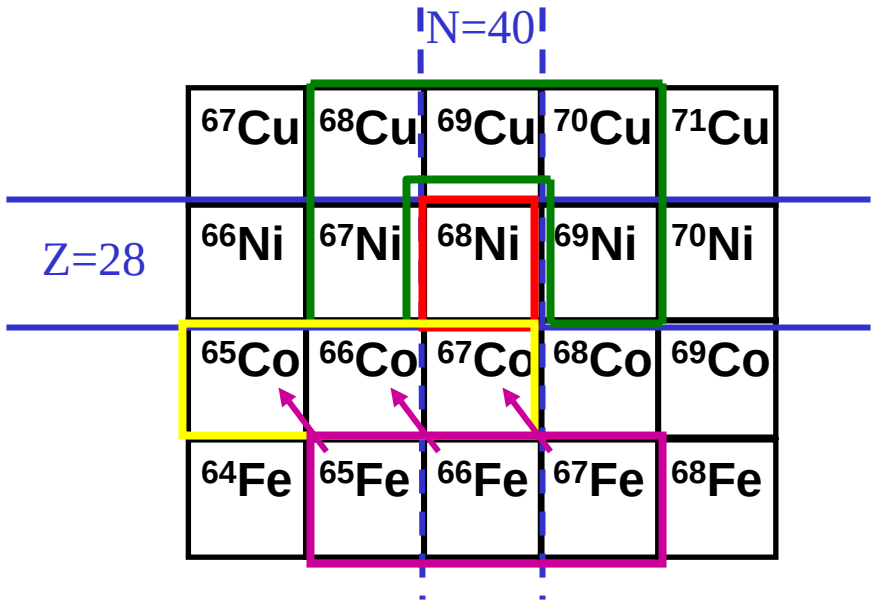




Nuclear structure study of Co isotopes at N~40

Fe, Co, Ni are refractory-type elements ⇒
Most studies were done using In-Flight separation method

No extensive β-decay studies were performed for Fe nuclei



$^{65\text{-}67}$Co isotopes are studied in the β-decay of $^{65\text{-}67}$Fe isotopes